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Visual soil examination techniques as part of a soil appraisal framework for farm evaluation in Australia

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ABSTRACT

Despite major advances in remote sensing and soil-landscape modelling, the use of visual soil examination and evaluation (VSEE) techniques in the field remains a crucial component of soil assessment and management packages for farmers in rural Australia. Of particular value are techniques for the rapid assessment of soil structural form and stability, which are fundamental issues affecting the ability of soil profiles to accept and store water in farming systems constrained by drought. An improved soil appraisal framework for farm evaluation, usable for all crops, derived from the successful VSEE-based 'Cotton SOILpak' system, is proposed. It has the potential to enhance the ability of farm businesses to deal with four soil-related issues; annual profitability, maximising land values, minimising the impact of increasing input costs, and negotiation of favourable outcomes for themselves and the local community when confronted by competing land uses. An overview is given of the proposed technical contents of the new scheme for 'whole-farm soil assessment and management planning', which is based on a blend of VSEE methods, modern soil databases, and extra laboratory testing where appropriate. Also outlined are the associated human resource requirements and organisational structures required to deliver practical and ethical soil management outcomes to farmers and the nation.

1. Introduction

Visual soil examination and evaluation (VSEE) techniques (Boizard et al., 2005) are of immense value for soil management, particularly methods associated with the rapid assessment and optimisation of soil structural form (Kay, 1990). They complement newly developed techniques for soil assessment such as remote sensing and soil-landscape modelling, and well established procedures such as laboratory analysis of soil samples.

Unfortunately, the application of packages for soil assessment and management across the globe has been inadequate: land degradation issues are widespread and continue to become worse in many areas (Cribb, 2010). The soil science community must bear some of the responsibility for poor application of its knowledge to clients who require assistance. Bouma (2001) has noted that if soil scientists are to remain relevant in our modern network society, they must learn to listen to and to communicate with their stakeholders, learn to present their expertise in a flexible manner and, from the beginning, become thoroughly engaged in settings of joint learning and negotiation. This paper responds to Bouma's challenge by examining client requirements for information about soil assessment and management in rural Australia. A framework that builds on existing decision support systems is proposed for the integration of VSEE procedures with other types of soil related information so that land degradation problems can be addressed more effectively in conjunction with clients. Possible linkages with professional accreditation schemes and training providers also are explored.

2. Soil information deficiencies on Australian land used for farming and grazing

2.1. As experienced by individual farmers

Much of the farmland in Australia is owned by family farmers/graziers (referred to collectively in this paper as "farmers") who live on their properties and manage the farms as family-owned enterprises. Subsidies from government are minimal, relative to farmer support programs in USA and Europe. Involvement by the author with 67 VSEE training workshops (1998–2011; mainly government-funded via Catchment Management Authorities) for approximately 900 farmers and their advisers in New South Wales, Queensland and Western Australia allowed him to conclude that there are four major soil-related issues requiring attention by Australian farm businesses:

2.1.1. Annual profitability

Farm profitability is a key issue for landholders who aim to maximise the output of high quality produce, and to minimise

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costs by making efficient use of inputs such as water and fertilisers.

Climatic extremes – prolonged drought and high temperatures in the period 2001–2009, followed by unusually wet conditions in 2010–2012 – have severely impaired the magnitude and continuity of farm income in eastern Australia. The problems with hostile weather have been aggravated by soil limitations. For example, sodicity is a widespread subsoil constraint that can retard soil water intake and storage in dry years, when extra soil water means improved plant growth, but creates waterlogging and trafficability problems under wet conditions that also limit progress (So and Aylmore, 1995). Often there is a poor match between soil requirements of the crop being produced and subsoil characteristics such as salt concentrations and pH.

Many farmers have soil test information provided via agronomic advisers but it usually only applies to the topsoil (0–10 cm or 0–7.5 cm), with a focus on plant nutrition (Brown, 1999). The soil information tends to be stored by farmers in their offices in an ad hoc manner that is difficult to access and hard to interpret. Important soil physical factors such as compaction severity and water holding capacity generally are overlooked. This lack of a clear and comprehensive approach to soil constraint definition means that inappropriate fertiliser products often are selected by farmers. Soil survey databases are provided by Australian state governments – for example, Soil and Land Information System (SALIS) in NSW – to give soil data that extends deeper than 10 cm, but the sampling sites usually are too widely spaced to be of value for field-by-field decision making. Farmers who intend to stay on their properties and make the most of future production opportunities therefore need to assess their topsoil and subsoil much more thoroughly, and present the results more clearly, so that their soil management regimes can be optimised in conjunction with other professionals.

2.1.2. Land values

Maximising farm value is a big motivator for Australian farmers. Some have large debts and want a dignified departure from farming through selling of their land. Farmers understand that soil is an extremely important part of their business venture. However, often there is anxiety about a thorough quantification of their soil condition because of fears about an embarrassing conclusion that may reduce the sale price for their farm.

Soil condition is recognised as a key factor in rural land valuation (Baxter and Cohen, 2009). Two distinct approaches are available: (1) comparisons with recent sales in a district, which tends to overvalue the worst land and undervalue the best land; and (2) an income based assessment that may overlook attractive cost–benefit ratios for repair strategies.

A fair sale is said to have occurred when an amiable negotiation has taken place between '*a willing but not anxious seller*' and '*a willing but not anxious purchaser*', both of whom are supposed to be well informed about the condition of the land under consideration (Baxter and Cohen, 2009).

A lack of objective data about soil condition in most sales transactions means that land with a severe productivity constraint that can be repaired in a cost-effective manner (for example, poor topsoil structure that is preventing a large percentage of the rainfall from entering a soil) tends to be undervalued because the potential for improvement usually is not factored into the valuation process. Farmers who have gone to the trouble of repairing degraded land often are not rewarded properly for their efforts when selling their land, despite improvements in short-term and long-term profitability. Sometimes agricultural land is overvalued; for example, where severe subsoil acidity remains undetected.

This data-poor transaction process contrasts strongly with the premium wine regions of France where 'per hectare' vineyard values can be as high as A$6-10 million. The soil characteristics of these sites – particularly geochemical composition and structure – and the associated wine quality are well understood, in conjunction with other environmental aspects of the 'terroir' of a site (Halliday, 2009).

At a minimum, Australian farm valuers – and the buyers and sellers of agricultural land – need a quick and inexpensive system of soil evaluation for both the topsoil and subsoil to provide outcomes that are more equitable than the current procedures. VSEE techniques can provide the foundation for such a scheme. Procedures that give a more accurate and comprehensive measurement of soil fertility and associated processes can then be applied at key sites identified by 'first approximation' VSEE methods.

2.1.3. Predicted increases in the cost of agricultural inputs

Australian agriculture is highly dependent on affordable supplies of fuel and nitrogen fertilisers derived from crude oil and natural gas. Expected shortages of liquid fossil fuels in the near future will force farmers to become even more efficient with their use of inputs that will become more expensive. Predicted 'peak phosphorus' constraints will provide similar challenges (Cribb, 2010). The threats associated with 'peak oil' and 'peak phosphorus' mean that farmers will have to focus on improvement and maintenance of good soil structure to allow maximisation of the efficiency of use of nitrogen and phosphorus fertilisers. Beneficial soil organisms such as nitrogen fixing bacteria and P-scavenging fungi require encouragement through provision of adequate habitat (favourable soil structure), suitable food (organic matter) and sufficient water.

2.1.4. Negotiations with mining and gas extraction companies

Mineral resources beneath Australian farms are the property of governments which grant exploration licences and land access rights to geological exploration companies. In the states of New South Wales and Queensland, the rapid expansion of coal and coal-seam-gas developments into agricultural land has created uncertainty for farmers. Regional planners within state government are developing procedures for the protection of 'prime agricultural land' from mining developments, with assessment based on schemes such as the NSW Agricultural Land Classification (Hulme et al., 2002) and the NSW 'Land and Soil Capability' scheme (Murphy and Taylor, 2008). Where land is to be developed for mining, farmers with high quality soil information are likely to be in a better position to negotiate a fair deal with 'Infrastructure Development Teams' from mining and gas extraction companies than farmers with poor information about the soil on their properties.

2.2. In relation to community expectations

Soil scientists in the Australian and global communities are expected to provide soil information for decision makers who have to deal with the following challenges:

- Assurance of national and global food security despite an expanding human population, finite production inputs and increasingly difficult climatic conditions (Cribb, 2010);
- Optimising the use of water resources; within Australia, attention has turned to the tropical north where there is a much greater amount of under-utilised water flow in rivers than in southern areas such as the Murray-Darling Basin, but soil information is sparse;
- The need to provide 'ecosystem services' such as soil carbon sequestration on a large scale, and minimisation of emissions from the soil of 'greenhouse gases' (carbon dioxide, nitrous oxide, methane), to reduce the rate of global warming;